Does Resource Commercialization Induce Local Conservation?

A Cautionary Tale From Southwestern Morocco

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Abstract:

Ecotourism, bioprospecting and non-timber product marketing have been promoted recently as market-based instruments for environment protection, but without sound understanding of the resulting net conservation effects. We present evidence on the local conservation effects of recent argan oil commercialization in Morocco, which seems a promising case study in conservation through resource commercialization. Our empirical analysis shows, however, that resource commercialization is not creating strong net conservation incentives because assumptions implicit in the prevailing logic prove incorrect in this case. Generally, the experience of southwestern Morocco provides a cautionary tale about the assumed efficacy of conservation strategies founded on resource commercialization.

I. Introduction

The past decade has witnessed widespread experimentation with market-based instruments for environment protection, including industrial emissions trading and transferable quotas in fisheries in wealthy countries and the promotion of ecotourism, bioprospecting, game cropping and non-timber forest product marketing in poorer countries. Although such efforts appear to work well in some settings, a sufficient mass of empirical evidence does not yet exist to permit clear determination of the efficacy of such methods in achieving conservation objectives. This is perhaps especially true with respect to tropical forests. Ever since Peters et al. (1989) showed that a tract of rainforest could, under certain conditions, be more valuable if sustainably harvested than if logged or converted to pasture, environmentalists have eagerly embraced resource commercialization as a conservation strategy. Ecotourism, bioprospecting and the marketing of non-timber products have thus been aggressively promoted in recent years, but without a sound understanding of the actual net conservation effects of such efforts. This paper makes a contribution toward filling that void.

We present evidence on the local conservation effects of recent argan oil commercialization efforts in Morocco. The argan oil case is in part a bioprospecting story. European chemists recently discovered that the oil from the nut of the argan tree endemic to the dry forests of southwest Morocco exhibits desirable properties for cosmetics sold commercially throughout Europe, Israel and around the world. A dramatic expansion of marketing and processing of argan oil, complete with induced institutional and technological change, has resulted (Lybbert 2000). The argan case is also partly a story of non-timber forest product marketing since argan oil commercialization requires ongoing nut harvesting and processing *in situ* because attempted introductions elsewhere in the world have achieved little success and synthetic substitutes have yet to be developed.

On its surface, the argan oil story seems promising as a case study in conservation through resource commercialization. Relatively poor forest dwellers produce argan oil, hold well-established access rights to the forest, and pose the principal threat to the forest via livestock browsing. Locals are therefore well positioned both to reap the rents resulting from an increase in the value of forest products that flow from resource conservation and to modify behaviors so as to achieve conservation. Our empirical analysis shows, however, that resource commercialization is not creating strong net conservation incentives. Indeed, the biology of the argan tree and the organization of markets for argan products together may cause oil commercialization to harm the argan forest in the long run. As we will show, the prevailing logic of conservation through resource commercialization fails because crucial implicit assumptions prove incorrect in the case of argan oil. The experience of southwestern Morocco thus provides a cautionary tale about the efficacy of conservation strategies founded on resource commercialization.

II. The Argan Forest

The argan tree (*Argania spinosa* (L) Skeels) is endemic to Morocco, where it covers 867,000 hectares (ha), second in coverage only to the cork oak tree. The argan tree is unique and ecologically valuable. It is the only species of the tropical family *Sapotaceae* remaining in the subtropical zone, and its deep roots are the most important stabilizing element in the arid ecosystem, providing the final barrier against the encroaching deserts (Morton and Voss 1987, Mellado 1989, M'Hirit et al. 1998). The argan forest lies primarily within the provinces of Agadir, Taroudant, Tiznit, and Essaouira, hereafter termed the Argan Forest Region (AFR).

Despite this dependence, argan forest cover fell by half during the 20th century. A change assessment in two communes of the Province of Taroudant indicated a significant drop in vegetation cover on 43% of the land area in this region from 1981-87 (Bakkoury 1999). Many organizations are now devoting considerable resources to conservation of the AFR. Central to these efforts is the commercialization of argan oil, a product extracted from the fruit of the argan tree with notable cosmetic, medical and nutritive properties. This has led to a sharp expansion of demand for argan oil in non-traditional, urban and overseas markets, on which more in section IV.

Tenurial arrangements in the AFR, composed of customary, legal and Qur'anic elements, reflect argan's importance in Berber society by giving preferential treatment to the collection of argan fruit over all other activities (DePonteves 1989, De Ponteves et al. 1990). Ownership of an argan tree is separate from grazing rights to the land around the tree, which may be separate from ownership of the land on which the tree grows. These rights are further divorced from access to argan fruit and wood.

Clearly established rights dictate both spatial and temporal use of the forest. Spatially, the argan forest is unofficially divided[1] into large tracts assigned to villages. These village tracts of forest land are subdivided into two categories of usufruct: communal and quasi-private. On the communally-managed tracts, called *azroug*,[2] all rights are held communally by residents of the village to which the tract is assigned. Within the bounds of the *azroug*, villagers are allowed to exercise their usufructuary rights, with the exception of cultivation, on a year round basis. Like much common property around the world, the *azroug* is typically quite degraded. Generally a village*'s azroug* is nearby, although households' dispersion results in differential access to *azroug* resources among households holding identical rights.

All land in the village*'s* forest tract not designated as *azroug*, typically a majority of the total area of the tract, is subdivided into quasi-private *agdal* units that are distributed to individuals in the village. Possession of an *agdal* grants an individual exclusive harvest rights to the argan fruit, whether in the tree or on the ground in his *agdal.*

Customary usufructure arrangements also divide the forest into two distinct periods. During the communal grazing period, roughly from mid-September to mid-May, AFR households communally exercise their usufructuary rights and are free to do so on their own private land or on the state forest tract assigned to their village, regardless of whether the land has been designated as *azroug* or *agdal.* Then, around mid-May or early June, regional appointed officials formally open the *agdal* season,[3] or fruit harvest, at which point individuals[4] begin to exercise exclusive harvest rights within the bounds of their *agdals.* A household is free during the *agdal* season[5] to exclude others, including their neighbors within the village, from their *agdal* by constructing a temporary enclosure around their assigned trees. Only the *azroug* remains open for communal grazing during this season and a household must graze or browse their livestock either on their own *agdal* or on the *azroug,* which is understandably more crowded during the *agdal* season. This seasonal crowding contributes significantly to forest degradation in the *azroug.* The temporal and spatial dimensions of the argan forest tenure system are characterized in Figure 1

Today, the greatest threats to the argan forest are due to the intensification of livestock browsing and grazing and the expansion of urban and rural settlements. Livestock numbers have increased substantially (Lybbert 2000) and obvious signs of overgrazing and overbrowsing are everywhere in the argan forest. Browsing directly harms the existing, mature argan trees as goats will climb high into the branches of an argan tree to reach its fruit. Though less common, camel herds also browse in the argan forest, leaving an easily identified trail of broken branches in their wake. Overgrazing can cause soil erosion, affect the microclimate of the forest by reducing ground cover and humidity and increasing temperature, and impede the long term regeneration of the forest.

III. The Logic of Conservation Through Resource Commercialization

With the biological and institutional details of the argan forest in mind, we turn now to the question at the core of this paper: does resource commercialization necessarily induce increased local conservation? The logic of conservation through resource commercialization is clear and compelling on its surface. The gross present value of conserving the underlying resource, R, is just the discounted stream of benefits produced from sustainable harvest,

(1) $$R = p_b \sum_{t=0}^{\infty} \rho^t B_t$$

where p_b is the price of the biological product, D is the discount factor (equal to 1/(1+r), where r is the discount rate) and B_t is the period-specific physical flow of product from the resource, in the present case, fruit production by the tree conditional on its age. Successful resource commercialization aims to increase demand for the biological product, thereby increasing p_B and, thus, locals' valuation of the underlying biota. The gross present value of the resource is obviously unit elastic in product price; for every one percent increase in the price of a harvested product, the underlying resource value likewise grows by one percent. Doubling or tripling of resource prices, as has occurred in the argan oil case, is thus expected to make natural capital an attractive investment for local resource owners, inducing conservation of existing forest and even planting of new trees. This logic permeates most arguments for resource commercialization as a conservation strategy.

At least five important assumptions underpin this tidy logic. First, it is assumed that resource owners capture the present value of resource production. This requires that commercialization increases the price received by the resource owner. While this may occur on average in a region, as we demonstrate later, the organization of product marketing may exclude important subpopulations of resource owners, in which case the process may end before it can ever begin in the areas they control because they don't sell the product or don't get a higher unit value post-commercialization. This assumption also requires a modicum of tenure security. As tenure becomes less secure, resource owners' *expected future* harvest, along with R, decreases. Second, so long as time preferences cause people to discount the future, the biology of the resource, as manifest in the production sequence B_t, dictates the magnitude of the increase in resource value. Unit elasticity refers to the proportionality of the increase in value. But if resource product does not arrive for many years, as is the case with some slow-growing species such as argan trees, then even a tripling of value yields only meager absolute gains because the base period resource value is so low. The implicit assumption is that those increased absolute gains are always sufficient to justify the opportunity cost of conservation, which is not always true. Third, the simple model above assumes that B_t is exogenous to individuals' harvest decisions. If one allows for a slightly more sophisticated specification of the population dynamics of the resource, then over-harvesting of B can affect the resource's recruitment rate. Put more simply, if people harvest more of an increasingly valuable natural product that is also essential to regeneration of the resource, as is the case for nuts, then even a protected forest may collapse in time. Fourth, the increased wealth that results from increased prices and resource values may induce either tenurial change or investment in other assets that threaten the target resource. Fifth and finally, it is commonly assumed that local social and cultural conditions are such that locals respond to economic incentives by either making conservation investments in the resource or by altering behavior that directly or incidentally harms the resources. The sections that follow explore these five assumptions in turn.

Throughout the remainder of the paper we exploit data collected during extensive fieldwork in the AFR, including a household (HH) survey in the Smimou *Caidat*, a county-like administrative unit located in the Essaouira Province in southwest Morocco. Villages were stratified by forest density (low, average and high), then two villages randomly selected from each stratum.[6] HHs within selected villages were stratified according to the number of *agdal* rights held and then randomly selected from each *agdal* wealth category. The survey was fielded separately with the male and female heads of 117 HHs.[7]

IV. Commercialization of Argan Oil: Are locals capturing the full value of their trees?

The indigenous Berber tribes of the AFR have relied for centuries on argan oil as a key element of their diet and used the oil as a moisturizer for the skin and hair, as well as an effective healing agent for minor wounds and a treatment for everything from rashes to diabetes. Yet not until perhaps 20 years ago were technical analyses performed on the oil to determine the veracity of these traditional Berber claims. Although these western-style scientific investigations have not been able to validate every claim, the studies consistently provide evidence in support of a number of argan oil virtues. This has sparked entrepreneurial activity by those who foresee lucrative non-traditional markets for this exotic oil and the nutritive, dermatological and even medicinal properties it seems to possess.[8]

In the push to understand the properties of argan oil more fully and to find a market for the oil, European cosmetic companies were perhaps the most keen and agile of the investigators. In the early 1990s these companies began adding small amounts of argan oil to their moisturizer products. By 1995, at least three cosmetic companies were using argan oil in their products, namely Galénique (product: Argane), Yves Rocher (product: Acaciane) and Colgate Palmolive (product: dermatological soap, Antinéa') (Charrouf 1995). Commercial argan oil distributors are also interested in tapping the high-value, domestic argan oil demand of tourists and middle and upper class urban-dwelling Moroccans. Today, the two most common argan oil products are edible oil, marketed as a cooking or salad oil, and cosmetic oil, marketed as a moisturizer and a treatment for wrinkles and a variety of dermatological ailments (e.g., acne, abrasions, rashes).

Most of the current export is to Europe and Israel.[9] In Israel, home to some 600,000 Moroccan immigrants, imported argan oil is sold for up to $35 per liter (Enneking 1998). While precise figures indicating the change in and current level of exports are unavailable or incomplete and unreliable, GTZ, the German aid organization that sponsors the largest network of argan oil cooperatives in the AFR, exported over 2,000 liters of argan oil in the first six months of 1999 and indicates that it is difficult to keep up with demand at times.[10]

These exporters quickly recognized, however, that traditional argan oil extraction and marketing were ill-suited to higher value markets. Consumers in these new, higher-price markets expect a higher degree of purity and higher quality oil and packaging than traditional argan oil consumers. Thus, argan oil could not simply be purchased at *souk* from local producers and resold for a premium in other markets. More sterile, mechanized extraction and more sophisticated marketing strategies were needed. This evolution in processing and marketing has meant that locals participate in emerging argan markets mainly by supplying argan fruit.[11]

Since argan fruit supply is inelastic in the short run, increased demand in argan fruit markets has resulted in higher fruit prices for locals, doubling from around 0.5DH/kg in the mid-1990s to over 1DH/kg. However, AFR locals have not uniformly benefited from increasing argan fruit prices. Even with the higher prices argan fruit has a low value-to-weight ratio, making long distance transport to market unprofitable. The argan fruit middlemen who have emerged to supply the needs of the growing market transport the fruit in lorries and therefore stick to markets that are easily accessible with good roads. Thus, locals in low density forest areas, which tend to be closer to roads and larger markets and are therefore more accessible, tend to have far greater access to argan fruit markets than their high density forest counterparts.[12]

The first assumption implicit in the commercialization-conservation logic also requires some degree of tenure security. As discussed previously, the tenure system of the AFR is seasonal. During the off-*agdal* season, locals theoretically cannot exclude others from using their *agdal* tracts. Nonetheless, the increased value of mature trees has given rise to a recent enclosure movement in which locals are constructing permanent barriers around their *agdals*. We discuss this trend in greater detail in the next section.

The distribution of rights in the forest does not rely on official titling procedures. Instead, locals often publicly establish and maintain their rights by cultivating barley in their *agdals*. Unfortunately, continual cropping of barley without significant fertilizer amendments can quickly deplete key nutrients in the soil, especially areas with an arid climate and already poor soil. Barley cultivation thus threatens the sustainability of the argan forest directly by impeding the natural regeneration process and indirectly by leaching soil nutrients. Furthermore, the desire to establish greater security over one's *agdal* via barley cropping intensifies as the value of argan fruit increases.

Finally, locals' tenure insecurity is illustrated by the periodic migration of massive Saharan camel and goat herds into the AFR.[13] During the summer of 1999, which followed a year of below average precipitation, a herd of over 7,000 camels, owned by an evidently wealthy pastoralist from the disputed Western Sahara, slowly trekked through the forest south of Essaouira, wreaking havoc to the forest during the *agdal* season. The accompanying camel herders completely disregarded the *agdal* rights of the local villagers and adamantly defended their right to the relatively abundant fodder.

In summary, locals in the AFR are unlikely to capture the full value of the argan oil commercialization because (1) they are not reaping the full increase in price due to market entry barriers that relegate them to fruit supplier status or leave them out of the market altogether and (2) their expected harvest is less than the expected production of the tree due to tenure insecurity. Furthermore, attempts to increase tenure security through barley cultivation may have negative implications on forest sustainability. As we discuss in the next section, the enclosure movement bodes well for conservation in *agdal* areas, but poorly for *azroug*.

V. Biology Matters

This section explores in greater analytical detail the positive direct effect of increased argan oil prices on the present value of argan trees and, derivatively, on conservation behaviors such as reforestation and protection from overgrazing. First we estimate a yield function for the tree and then incorporate discount rates and fruit prices to estimate the present value of argan trees. For most domesticated trees, such an activity would be very straightforward since the relationship between the age of a tree and its productivity is generally well understood. In the case of the argan tree, however, this relationship is more elusive because the tree has a unique mechanism for coping with frequent droughts. During unusually dry years, the argan tree goes dormant, stores its needed reserves deep in its root system and produces neither fruit nor foliage (Bani Aameur, Louali, and Dupuis 1998). Then, once there is sufficient precipitation, the trees begin producing again. Because does not produce rings during dormant periods, there is no reliable record of an argan tree's age and argan's fruit yield-age relationship has yet to be explicitly researched. A few argan researchers have made passing comments about the productivity of the tree (Table 1). Unfortunately, not a single reference links observed fruit production with a precise age of the tree. Nonetheless, these data provide information enough to estimate a crude argan fruit production function, assuming an exponential yield function $Q(t) = e^{a-b/t}$, where t is measured in years with t=0 representing the germination year, Q(t) is the production in year t measured in kilograms of dried fruit, and a and b are estimable parameters. The present value of an argan tree's fruit production (R) in discrete time is thus

(2) $$R = p \cdot \left(\sum_{t=0}^{100} \rho^{t} e^{a-b/t} \right)$$

where p is the price of argan fruit in DH per kilogram, ρ is the discount factor.[14] We fix the time horizon at 100 years since discounting effectively extinguishes the value of gains beyond this horizon.

Because some of the estimates in Table 1 conflict and because fruit production depends on precipitation and is therefore highly variable both temporally and spatially, we estimate two candidate yield functions, Y1 and Y2. Both use the specification above, but estimate the parameters a and b using different references from Table 1. The first yield function (Y1) borrows DePonteves' (1989) estimate that the argan tree's maximum fruit production is 100kg, which we assume occurs at t=200, the oft-cited age of maturity (M'Hirit et al. 1999). Additionally, Y1 assumes the upper bound on the range of average production in Table 1 occurs at t=60. These point estimates yield a=5.3 and b=138. The second candidate yield function (Y2) assumes maximum annual fruit production of 45kg/tree (Zahidi 1997) at t=140 (Koubby 1997)and average annual production of 15kg at t=40 (Rahali 1989). This calibratrion yields estimates of a=4.3 and b=61.5.

The production profiles of Y1 and Y2 are shown in Figure 2. The gross present value of the annual fruit harvest is shown graphically in Figure 3.[15] These present values assume p=1, roughly the current price per kilogram of dry fruit.[16] What is most striking about Figure 2 is that because the tree is slow growing and discounting takes its toll on the returns to fruit harvested far into the future, the maximum present value of annual fruit production is extremely low, about 1DH and 2DH for Y1 and Y2, respectively. Summing these annual present values across t=0,…,100 yields an R_{Y1} of only approximately 60DH at germination. R_{Y2} is 108DH, larger than R_{Y1}, but still rather small. By way of comparison, the average daily wage for a male laborer is about 35DH.

These low gross present values perhaps explain why spontaneous local reforestation has yet to occur. Locals have an incentive to plant only if the expected net present value is positive, that is, if the gross present value of a newly planted tree times the probability of the sapling surviving (i.e., the probability of actually reaping R), less any non-labor costs and any risk premium (associated with aversion to income risk) exceeds the (opportunity) cost of labor dedicated to planting and tending. Even if the *Service des Eaux et Forets* donates argan seedlings to locals free of charge, two or three days' labor planting and tending the tree makes it unremunerative, especially since the reforestation success rate is low as most plantings fail. In short, the low *net* expected present value of fruit production at germination is generally too small to make planting argan trees pay, even after a doubling of fruit prices in the wake of commercialization.[17] Survey evidence corroborates the qualitative finding of the preceding estimates. The survey asked both male and female HH heads, "If you were given a tree to plant on your property, what kind of tree would you prefer?" Olive trees were overwhelmingly most desired (Table 2). High density forest villages are practically the only ones in which any HH heads identified argan trees as their preferred species, indicating that these HHs' relative valuation of the argan tree is marginally higher than that of mid- and low density forest HHs in spite of lower relative scarcity and less marketing of argan fruit in the high density forest. This relative preference for argan trees among high density forest HHs is also likely due to the fact that tree productivity and forest density tend to be positively correlated, so trees' present value is likely higher in the high-density zones.

Male HH heads prefer the carob tree to argan in each region. Administrators at the Essaouira regional office of the *Service des Eaux et Forets* confirmed that carob seedlings are consistently in higher demand than argan seedlings because they more quickly produce marketable fruit and because a carob processing plant recently located in Essaouira, creating a substantial local market for carob fruit. Female HH heads in high density villages were more likely to prefer the argan tree than males, although they too uniformly prefer olive trees and none has actually planted or watered argan trees. In sum, spontaneous local reforestation is unlikely to follow directly from high argan fruit prices due to the tree's slow-growing biology.

The next logical question is whether commercialization induces better protection of existing trees. To answer this, we begin by estimating the present value of an existing argan tree's fruit production by shifting the time horizon in equation (2) forward from t=0,…,100 to t=(τ+1),…,(τ+100), where τ is in the age of the existing tree in years. The gross present value of fruit production now becomes

(3) $$R_{Yi:\tau} = p \cdot \left(\sum_{t=0}^{100} \rho^t e^{a-b/(t+\tau)} \right)$$

where i=1,2. $R_{Y1:0}$ is thus identical to our previous calculations of R_{Y1} at t=0 while $R_{Y1:60}$ is the gross present value of fruit production for a tree of age 60 years.

Figure 4 shows the present value of annual fruit production for τ=60. The profiles of Y1 and Y2 are very similar, with maximum annual present value of 20-25DH, as opposed to 1-2DH in the τ=0 case. $R_{Y1:60}$ is 695DH, and $R_{Y2:60}$ is 626DH, as much as an order of magnitude greater than $R_{Y1:0}$ and $R_{Y2:0}$. Table 3 shows how valuation changes depending on the initial age of the tree, underscoring that the conservation effects of resource commercialization apply to existing, mature forest but not to reforestation in this case.

The relative magnitude of $R_{Yi:60}$ helps explain the considerable value assigned to an *agdal* inheritance, as well as the recent *agdal* enclosure movement. A doubling or tripling of the price of argan fruit adds an estimated DH300-350 to the value of a mature tree that is already established, for which the risk of failure is much lower than at germination. This increase is equivalent to one to two weeks' earnings on the local labor market, easily enough to induce AFR residents to devote an extra couple of days' time to building fences. Generally, AFR locals appear willing to invest time and effort in enclosing their existing trees with permanent *agdal* barriers although they seem unwilling to invest time and effort in planting even free argan seedlings. Note, however, that for relatively impatient individuals (with relatively high implicit discount rates) even the value of an existing tree might not justify the extra effort required to protect it.

Once again, survey evidence corroborates the implications of these estimates. Male HH heads were asked whether they would cut down the argan trees on their property for either agricultural conversion or for the value of the wood if the *Service des Eaux et Forets* gave them permission. The majority responded that they would not cut their argan trees for either purpose, although the pressure to convert forest to agriculture appears significantly greater in low density villages (Table 2). Where a decade ago there was significant clearing of forest for fuelwood and agriculture in the AFR, in the wake of argan oil commercialization and resulting fruit price increases, the argan forest appears less threatened by direct conversion or clear-cutting. Rather, the key to conserving the argan forest now lies in addressing local threats such as overbrowsing.

We asked female HH heads, first, how frequently they allowed their goats to climb and browse in argan trees and, second, to assess whether overgrazing and/or overbrowsing were problems in the argan forest. To the first question, nearly all (95%) browsed their goats in argan trees frequently, which likely reflects the widespread perception that livestock are the most valuable assets to own in the AFR and that alternative browsing/grazing areas are quite scarce.

Responses to the second, overgrazing question were more instructive. In the high density forest villages, where trees are plentiful and the commercial benefits of argan fruit marketing have remain largely unchanged in the wake of commercialization, women do not perceive overgrazing to be a problem (Table 2). By contrast, roughly half the respondents thought overgrazing is a problem in the low and middle density regions, where the price increases due to commercialization have been significant.

Key informants report that increased argan fruit prices have indeed induced more forest-friendly browsing practices. The *Caid* (regional appointed authority) of Tamanar observed that since the arrival of the argan oil cooperative, locals are hesitant to allow their goats to browse in argan trees because they know that every piece of argan fruit their goats digest is one they could have sold to the cooperative. Other interviewees made similar observations regarding areas where fruit markets were accessible to collectors.

Even if households are not keeping their own goats out of their *agdal* trees, an enclosure movement has emerged to keep others out of one's trees. As fruit becomes more valuable and *agdal* holders become more protective of their fruit (or enclose their *agdal* tracts outright), what was previously communal forest land during the off-*agdal* season is effectively removed from the common pool resources. This de facto change in tenurial arrangements, though controversial, is increasingly common and appears to be gaining acceptance.

Increased protection of *agdal* forest is likely to cause greater degradation in *azroug* forest in so far as it displaces livestock from the former areas to the latter. The likelihood of locals' making efforts to protect *azroug* trees is low for two reasons. First, common property management problems have left *azroug* trees generally less productive and more degraded than *agdal* trees, so the present value of their fruit production is less. Second and relatedly, there are few if any traditional cooperative maintenance and management arrangements in the AFR, so *azroug* trees fall prey to classic commons problems: everyone has an incentive to exploit the tree but no one has an incentive to conserve it. Although the poorest HHs, who have relatively few or no *agdal* rights, would be most harmed by such an intensification of competition over and exploitation of common property resources, even those with plenty of *agdal* rights have an incentive to browse their herds more intensely in the *azroug* as the value of their *agdal*'s fruit production increases. It therefore seems that at least in the short-run, *azroug* trees will probably be degraded yet further as argan fruit prices increase because of displaced off-*agdal* season grazing, resulting from induced *agdal* enclosure.

In summary, the biology of the argan tree makes the present value of a newly planted tree low, so even a strong proportional increase in fruit prices has too modest an absolute effect on tree values to induce reforestation. Mature trees prove worth conserving, however, and the survey evidence appears to bear this out indirectly. More men declare no interest in converting argan forest and more women recognize livestock overgrazing to pose a serious threat to the forest. Moreover, an enclosure movement has begun in which people are undertaking costly investments in permanent barriers to exclude neighbors from traditional off-season access to *agdal* trees. The net conservation effect on the *azroug* regions to which livestock are being displaced now is almost surely negative, while the net effect in the *agdal* areas appears positive in the short-run. In the longer run, additional considerations come into play, to which we now turn.

VI. Harvest Decisions and Productivity

Reforestation in the case of the argan tree is a very difficult proposition. The extensive root system of the argan seedling, which extends deep into the soil at a remarkably young age, makes transplanting difficult and rarely successful. There is also evidence that argan seedlings are extremely vulnerable to various fungi (Bani Aameur 1997). Whatever the explanation, argan reforestation projects are plagued with exceptionally low success rates. In one well-organized experimental reforestation effort, only 11% of the argan seedlings planted survived for more than three months (Alaoui 1997). Since no appreciable human reforestation is currently taking place or is likely to be successful in coming years, the future of the argan forest depends entirely on natural regeneration, which requires that at least some fruit remains uncollected. Increasing fruit prices could negatively and directly affect the forest by making fruit too valuable to leave behind.

Some researchers worry that the long term sustainability of the argan forest has already been jeopardized by nearly complete fruit harvests in recent years (Bani Aameur 1997). Moreover, some claim that the microclimatic conditions have changed sufficiently as a result of thinning canopies (less shade) and overgrazing (less organic litter on the forest floor) as to seriously hamper the natural regeneration process (Zahidi and Bani Aameur 1996).

Our survey solicited local perceptions of this prospective overharvesting and regeneration problem. Table 4 reports that the proportion of female HH heads who believe all the argan fruit in the forest is collected is decreasing in forest density, with more than half the HHs in low density forest 'strongly agreeing' with the assertion that all fruit in the forest is collected. Where fruit is scarce and collectors have good access to markets now returning higher prices, few if any fruit are left to seed forest renewal.

In the short run, decisions about how to harvest are just as important to forest productivity as decisions about how much to harvest. Traditionally, locals harvested fruit from argan trees either by sending goats into the tree to browse on the fruit and later collecting the valuable stone in the goat manure or by waiting for the fruit to fall from the tree. As the fruit becomes more valuable, however, there is some anecdotal evidence that locals turn to more aggressive techniques, such as knocking fruit from the tree using sticks and stones. More aggressive harvesting methods, seemingly more common in areas with relatively weak tenure security, can damage trees and hurt natural forest regeneration.

VI. Indirect Effects: Investment and Tenure Change

The indirect effects due to commercialization-induced increases in local wealth are somewhat more difficult to assess. Livestock are the most desired form of household wealth in the AFR, where non-farm options are scant and crop cultivation offers poor returns. Consequently, at least some of the proceeds from argan fruit sales will likely be invested in livestock.[18] Since stocking densities and forest stress are positively correlated, this bodes poorly for argan forest conservation.

VII. Cultural and Social Considerations

It is important to recognize as well the cultural context of the argan forest. There exist two competing argan tree legends. The first traces the tree's origin to the prophet Mohammed, who was given stewardship over the tree by Allah and told to plant it liberally throughout southwestern Morocco. In this narrative, Mohammed is responsible for the providence of the argan tree along with all its bountiful uses. In direct opposition stands the second legend, which traces argan to Satan, who was permitted to use the tree to afflict and torment the Berber people (more specifically, the Berber women). Women ascribing to the second narrative explain that the tree is thorny and demands so much of their time that it distracts them from their other responsibilities; only Satan could be responsible for such a pestilence, they say. Most importantly, neither of these myths places ultimate responsibility for the argan tree with the locals.

Locals consider the argan tree 'wild', and seem to have never invested much time or effort in tending argan trees. In contrast, domesticated olive and carob trees do capture the locals' attention and investment. Understanding this perception of the argan tree is fundamental to the commercialization-conservation link. The Berbers routine denial of responsibility for argan trees diminishes the likelihood of direct individual investment in the argan tree. This cultural context may well evolve, but even if all four previous assumptions held, at least in the short run there are reasons to expect AFR locals' argan conservation behaviors not to respond much to higher resource values.

VIII. Conclusion

In this paper we assess the net local conservation effect of resource commercialization in the case of Morocco's argan oil. There are at least five important assumptions implicit in the standard logic to market-based approaches to conservation.. The ability of resource commercialization, whether via ecotourism, bioprospecting, or commercialization of non-timber forest products, to translate into appreciable net local conservation hinges critically on these underlying assumptions.

In the argan oil case, these assumptions are tenuous. Locals are not capturing the full value of the more valuable argan oil due to market barriers and tenure insecurity. Nevertheless, the development of high-value, non-traditional argan oil markets seems to have succeeded in increasing argan fruit prices and, derivatively, locals' valuation of the argan forest, as evident in the agdal enclosure movement. But it is unclear that local conservation is the logical consequence of this greater valuation. While *agdal* enclosure bodes well for the preservation of part of the argan forest, displaced exploitation and the incentives associated with local forest tenure seem to contribute to localized degradation in *azroug* forest.

Harvest decisions are not exogenous to the productivity of the argan tree. Specifically, the forest relies almost entirely on natural regeneration since reforestation efforts have largely failed. Unfortunately, overharvesting already threatens natural forest regeneration and could intensify as fruit prices increase. More aggressive harvesting techniques, if broadly adopted, could also threaten the short run productivity of the forest.

Even with recent fruit price increases, reforestation does not appear to pay because of the slow-growing nature of the argan tree. Conversely, protecting existing argan trees seems to pay quite well. This helps explain why locals are largely uninterested in planting argan trees, but are willing to invest in protecting their existing trees with permanent enclosures.

The indirect effects of AFR residents' investment of any gains from argan oil commercialization in livestock pose a serious threat to the forest. Induced tenure change is apparent in the argan forest. While this trend bodes well for parts of the forest, localized degradation due to displaced exploitation as well as illegal use complicate the assessment of the net conservation effect.

Locals traditionally take little responsibility, culturally or economically, for argan trees and so spend little or no effort tending them. While locals clearly recognize their reliance on the tree and are hence not inclined to deforest directly, they also perceive the tree as wild and are therefore not inclined to reforest either.

The argan oil case presents a promising case study for analyzing the conservation effect of resource commercialization because locals produce argan oil, possess well-established (if not always secure) rights to the forest and pose the primary threat to the forest. That critical implicit assumptions fail to hold in this case is evidence of the high standard imposed by these assumptions. The case of argan oil commercialization in southwestern Morocco thus serves as a cautionary tale about the challenge of using market-based efforts to induce local conservation in the tropics.

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[1] No official records exist that delimit precisely these demarcations, although local authorities are well aware of the traditional demarcation of each village's tract of forest land.
[2] This is the term in *Tashil'haite*, the Berber dialect. In Moroccan Arabic, the term *mouchaa* is used.
[3] *Agdal* (literally, "forbidden") is used to refer to both the fruit-bearing season and to the physical cluster of trees for which usufrutuary harvest rights are granted to a particular individual. For clarification, '*agdal* season' will refer hereafter to the fruit-bearing season while '*agdal*' will refer to the cluster of trees assigned to an individual.
[4] Strictly speaking, while *agdal* rights are technically assigned to individuals, generally these rights are actually exercised by households, rather than by individuals.
[5] The length of *agdal* is determined by regional appointed officials, who also are responsible for resolving user conflicts in the forest, and varies according to level of precipitation and the resulting productivity of the forest. During extraordinarily dry years, which cause the tree to shed its foliage and temporarily curtail fruit production, the *agdal* season may be foregone altogether.
[6] To sort villages in the Smimou *Caidat* into low, average and high argan forest density, we consulted local and regional forestry officials in conjunction with topographical maps and a 1996 forest inventory.
[7] Sampling proportions across villages ranged from 23-34% and have been corrected for in all aggregate statistics reported here.
[8] Markets for argan oil did exist historically in local *souks*. The non-traditional markets being sought presently include upscale markets in Moroccan cities targeting both Moroccans and tourists, as well as international markets for exotic oils.
[9] Small samples of argan oil are shipped occasionally to the US, Canada or Japan and at least one of the firms involved is actively seeking to establish distribution channels in the US (see www.arganoil.com).
[10] Per interview with Mr. Slimane Aziki, one of the cooperative project managers at GTZ.
[11] Traditionally, locals commonly fed whole argan fruit to their livestock, primarily goats, and then harvested the argan stones from the manure. These stones were then cracked to remove the oil-rich nut which was then crushed to extract the oil. Emerging high-value producers, concerned about the possibility of residual impurities from goat ingestion, are therefore only willing to purchase whole argan fruit from locals. The attached pulp is essentially a guarantee that the fruit has not been ingested by livestock. For more on various signaling mechanisms to resolve asymmetric information in argan product markets see Lybbert (2000).

In addition, locals face severe infrastructure and credit constraints, which preclude most locals from participating directly in the emerging markets via mechanized extraction.
[12] Our survey data show that while high density forest households sold twice as much argan oil at *souk* than mid- or low density forest households, not a single high density household sold argan fruit. In contrast, many households in mid- and low density forest regularly sold argan fruit.
[13] These massive and destructive migrations have both a climatological and a political explanation. Climatologically, these livestock owners were bringing their herds north in response to the paucity of fodder in the Western Sahara, the result of an unusually dry winter and spring. The migrations were ignored because of the political conflict surrounding the Western Sahara. No local official dared impede them for fear of instigating what could quickly escalate to national crisis.

[14] The discount factor is calculated as $\boldsymbol{r} = \frac{1}{(1+r)}$ where r is the discount rate. We initially assume r=0.05. Prevailing inflation and nominal interest rates in rural Morocco over the past few years have averaged 4% and 9%, respectively.

[15] These gross present values represent an upper bound estimate of the annual returns to planting an argan tree since the costs of harvest are not included in the computation.
[16] This price is nearly double the historical average thanks to recent commercialization and mechanization efforts.
[17] As these production functions are crude estimations, it is also helpful to analyze the elasticity of $R_{Yi:0}$ and $R_{Yi:60}$ with respect to the estimated production points Qmax, Q(60) and Q(40), and the discount rate, r. All four Qmax arc elasticities are inelastic, indicating that our crude present value estimates are only mildly sensitive to Qmax. These elasticities indicate that the estimates of the present value at germination

are especially sensitive to the assumed annual production at these midpoints since these midpoints affect the shape of the production profile early in the time horizon when the value of production is least discounted. Finally, the elasticities of $R_{Yi:0}$ and $R_{Yi:60}$ with respect to the discount rate, r, illustrate how extremely sensitive the estimated present value of fruit production is to discounting. The values of these elasticities are available upon request.

[18] While some of the proceeds might conceivably be invested in additional *agdals* of argan trees, the market for these assets has historically been quite illiquid.

<table>
<tr><td colspan="2"></td><td colspan="3">Spatial Dimension</td></tr>
<tr><td colspan="2" rowspan="2"></td><td colspan="2">State Forest Land</td><td rowspan="2">Private Land</td></tr>
<tr><td>Agdal</td><td>Azroug</td></tr>
<tr><td rowspan="3">Temporal Dimension</td><td>Jan
Feb
Mar
Apr</td><td colspan="2">Communal grazing and the exercise of other 'ancestral' rights.</td><td rowspan="3">Individually-exercised cultivation, grazing, etc.</td></tr>
<tr><td>May
Jun
Jul
Aug
Sep
agdal season</td><td>Individually-exercised harvest (agdal) rights.</td><td>Intensive communal grazing, etc.</td></tr>
<tr><td>Oct
Nov
Dec</td><td colspan="2">Communal grazing and the exercise of other 'ancestral' rights.</td></tr>
</table>

Figure 1 Dimensions of argan forest tenure

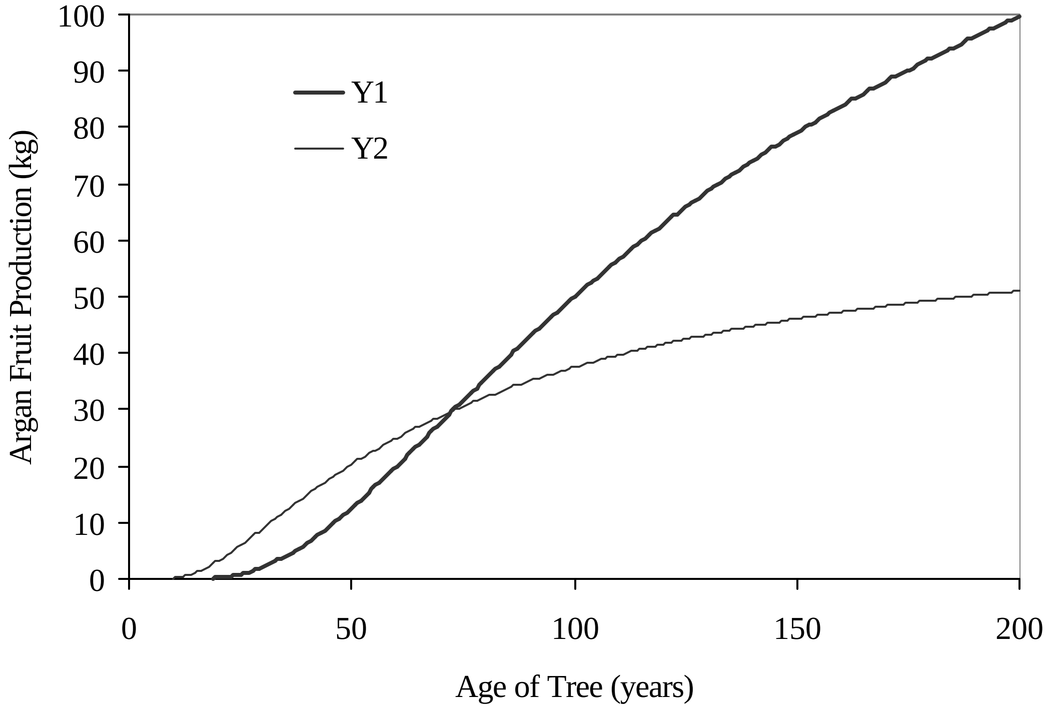

Figure 2 Y1 and Y2 production profiles

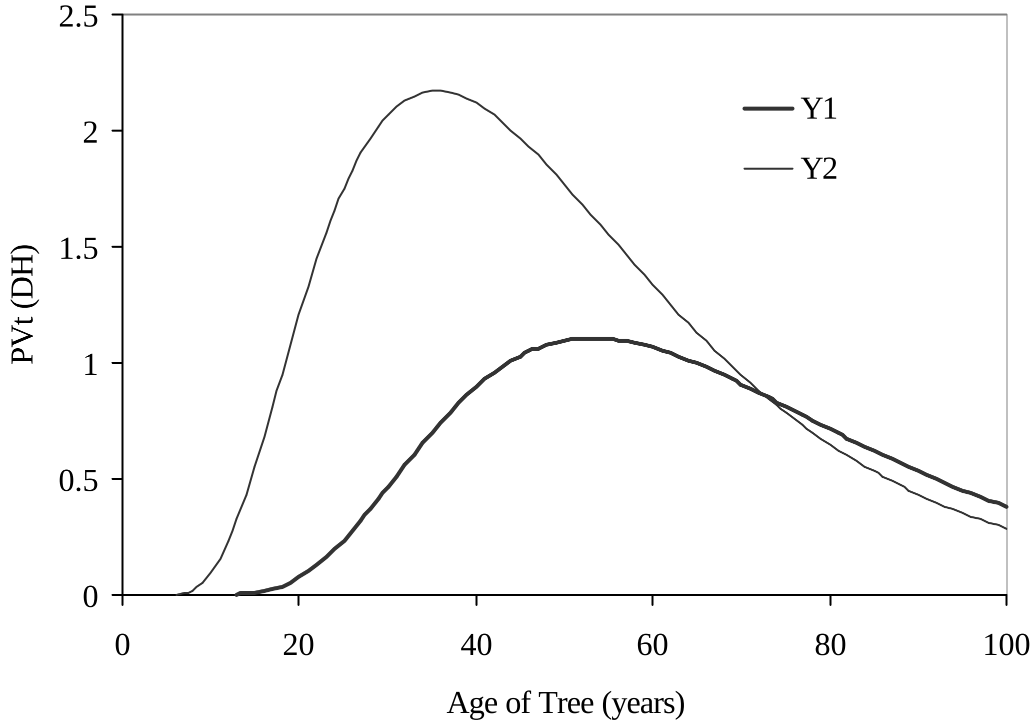

Figure 3 Gross PV at t=0 of annual fruit production for Y1 and Y2 (based on (5.8); t in years, p=1, r=0.05)

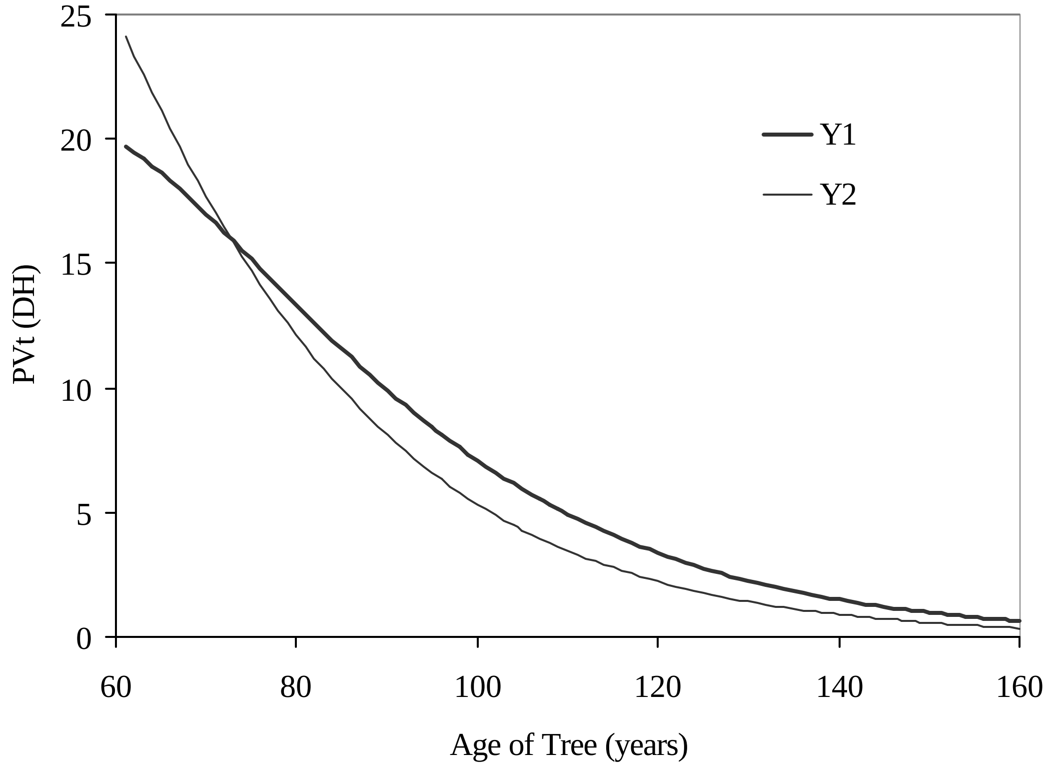

Figure 4 Gross PV at τ=60 of annual fruit production for Y1 and Y2 (based on 5.9: t in years, p=1, r=0.05)

Table 1 Estimates of argan tree productivity and age

Reference	t (years)	Q(t) (kg/tree)
Rahali (1989)	Average	15
DePonteves (1989), Mhirit (1999)	Average	8-20
DePonteves (1989)	Maximum	100
Zahidi (1997)	Sample	3-45
Boudy (1950), DePonteves (1989)	5	Begins fruit production
Koubby (1997)	60	Production levels off
	140	Production begins to fall

Table 2. HHs' conservation-related characteristics and attitudes

			Density Categories		
		Sample	High	Mid-	Low
"If given a tree to plant, what kind would you prefer?"[a]					
Male Head	Carob	11%	21%	5%	5%
	Argan	3%	7%	-	-
	Olive	82%	69%	92%	84%
Female Head	Carob	7%	10%	5%	5%
	Argan	9%	24%	3%	-
	Olive	67%	52%	68%	81%
"If permitted, would you cut your argan trees to…"					
...facilitate agriculture?	Yes	10%	2%	8%	22%
	No	88%	98%	84%	78%
...procure wood?	Yes	8%	7%	13%	3%
	No	91%	93%	79%	97%
"Overgrazing is not a problem in the forest."					
	Agree	62%	83%	45%	54%
	Disagree	32%	12%	45%	41%
	N=	116	42	38	37

[a] Carob, argan and olive were the three most frequently cited species. Other species were also cited, but are not included here. Elsewhere non-response is responsible for question percentages totaling less than 100%.

Table 3 Gross PV_τ for $t=(\tau+1),\ldots,(\tau+100)$ (t and τ in years, p=1, r=0.05, $R_{Yi:\tau}$ in DH)

τ	$R_{Y1:\tau}$	$R_{Y2:\tau}$
0	60	86
10	102	150
20	172	241
30	275	337
40	404	424
50	547	499
60	695	563
70	840	618
80	980	666
90	1112	707
100	1236	743

Table 4. Household perceptions of harvest completeness

			Density Categories		
		Sample	High	Mid-	Low
"ALL argan fruit in the forest is collected."*					
	Strongly Agree	36%	21%	32%	57%
	Agree	2%	2%	3%	-
	Indifferent	11%	24%	8%	-
	Disagree	16%	24%	16%	8%
	Strongly Disagree	34%	29%	39%	35%

* Percentages represent the female HH heads' categorical responses to this statement

Table A-1 Arc elasticities of PV calculations with respect to (w.r.t.) estimated production points and discount rate

	Elasticity of			
w.r.t.	$R_{Y1:0}$	$R_{Y1:60}$	$R_{Y2:0}$	$R_{Y2:60}$
Qmax	-0.30	0.25	-0.15	0.48
Q(60)	1.30	0.70		
Q(40)			1.22	0.50
r	-2.20	-1.10	-1.82	-0.97